

REMARKS

Claims 1-20 were submitted for examination, and all claims have been rejected.

Applicants are hereby amending claims 1, 7, 12, 14, 15 and 18 and request that the Examiner reconsider all claims in view of the following remarks.

Applicants have amended claims 1, 7, 12, 14, 15 and 18 to make clear that their claimed invention employs two or more angle coordinates for each pixel to represent directional information for the pixel. The angle coordinates are estimated or interpolated from values of angle coordinates associated with vectors at the vertices of a polygon containing the pixel. This eliminates the computational cost of interpolating the vectors themselves for each pixel.

Claims 1-20 have been rejected under 35 U.S.C. §103 as being unpatentable over U.S. Patent No. 5,949,424 of Cabral et al. ("Cabral") in view of 3D Studio MAX ("Studio MAX"). Applicants respectfully traverse this rejection.

As noted in the previous amendment, Cabral teaches the use of a tangent space transformation module to transform a lighting vector and a viewing vector into a tangent space and a bump mapping module to interpolate and normalizes the tangent space lighting and viewing vectors. The bump mapping module performs a vector operation, e.g. a dot product, on the tangent space lighting vector and the perturbed normal vector for each pixel (col. 4, lines 1-22).

Thus, Cabral requires the determination of vectors for each pixel and the attendant computational overhead to determine lighting effects. It is this computational overhead that is avoided by Applicants claimed invention.

Specifically, Cabral fails to disclose the use of pairs of angle coordinates associated with a vertex vector of a polygon. Cabral also fails to disclose the use of these angle coordinates to

determine angle coordinates for each pixel of the polygon, as in Applicants' claimed invention. The use of vertex angle coordinates to estimate angle coordinates for each pixel eliminates the computational overhead associated with interpolating and normalizing vectors for each pixel, which is the mechanism taught by Cabral (col. 4, lines 15-17).

The Examiner contends that Cabral teaches the use of angle coordinates at col. 4, lines 3-6. As noted in the previous amendment, the reference to a "half angle" in this passage is a misprint that should read "half angle vector", a term that appears in full throughout the specification. Even ignoring this misprint, there is no reference to pairs of angle coordinates or estimating such pairs of angle coordinates from vertex angles, as is claimed by Applicants.

The Examiner also contends that Cabral discloses the use of angle coordinates at col. 6, lines 36 - 40. However, the referenced passage explicitly states that "**shading vectors are transformed on a per pixel basis**" (emphasis added). There is no discussion of pairs of angle coordinates for each pixel, or determining such angle coordinate pairs for each pixel from vertex values, as in Applicants' claimed invention.

The Examiner also appears to argue that even if Cabral does not disclose the use angle coordinates, such coordinates could be computed from the vectors determined by Cabral (paragraph 8 of the office action). Cabral's determination of the lighting vectors themselves obviates any need to make such computations, since lighting effects may be determined using either representation of per pixel directional properties (lighting vectors or angle coordinates) alone. Adding the computation of such angles to the method disclosed by Cabral would simply add to the computational overhead of interpolating and normalizing the lighting vectors. Applicants' claimed invention avoids this overhead altogether by working with scalar angle coordinates.

The Examiner acknowledges that Cabral fails to disclose either a table of color values or assigning these color values to pixels according to one or more color variables. The Examiner cites Studio MAX for its disclosure of a UV map.


Applicants note that Studio MAX does not teach the use of angle coordinates in bump mapping nor does the Examiner suggest that it does. Regardless of what Studio Max may disclose about color tables, it fails to remedy the above-noted deficiencies of Cabral.

Applicants thus submit that independent claims 1, 7, 12, 15, and 18 are patentably distinguished over any combination of Cabral and Studio Max. Claims 2-6, 8-11, 13-14, 16-17 and 19-20 depend from independent claims 1, 7, 12, 15 and 18, respectively, and are patentably distinguished over Cabral and Studio Max for at least the foregoing reasons.

In view of the foregoing remarks, Applicants respectfully submit that the rejections of the claims submitted for examination have been overcome, and that the now pending claims are in condition for allowance. If the examiner disagrees or believes that further discussion will expedite prosecution of this case, he is invited to telephone applicant's representative at the number indicated below.

"Express Mail" mailing label number: EL6171838 MUS
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Yours truly,

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Version With Markings to Show Changes Made In the Specification

1. (Twice amended) A method for implementing bump mapping, comprising:

generating a table of color values referenced by orientation-dependent color variables;

determining first and second vertex angle coordinates for a vertex vector;

[estimating] interpolating the first and second vertex angle coordinates to provide first and second angle coordinates for [a] each pixel in a polygon, the first and second angle coordinates representing a direction of the vertex vector at the pixel;

modifying the estimated angle coordinates, using a perturbation source;

converting the modified angle coordinates to one or more color variables; and

assigning the pixel a color value according to the one or more color variables.

7. (Twice amended) A graphics system comprising:

a geometry engine to associate vector orientation data with vertices of one or more polygons representing an object in an image;

a color map including color values for a sample of vector orientations, each color value being referenced by one or more orientation dependent color variables;

a perturbation source to provide orientation perturbations; and

a rendering engine to convert a vertex [data for each polygon] vector and a vertex perturbation to a pair of vertex angles and a pair of vertex perturbation values, respectively, estimate pairs of angle coordinates and perturbation coordinates for each pixel in the polygon from the pairs of vertex angles and perturbation values, respectively, generate one or more perturbed color variables using the angle and perturbation coordinates, and assign a color value to each pixel according to its one or more color variables.

12. (Twice amended) A machine readable medium on which are stored instructions that are executable by a system to implement a method for assigning a color value to an image pixel, the method comprising:

generating color values for a sample of normal vector orientations, each color value being associated with one or more scaled angle coordinates representing a corresponding normal vector orientation;

estimating first and second angle coordinates for the pixel from angle coordinates associated with a vertex vector;

perturbing the first and second angle coordinates to provide modified first and second angle coordinates; and

retrieving a color value for the pixel according to the perturbed first and second angle coordinates.

14. (Twice amended) The machine readable storage medium of claim 12, wherein estimating comprises:

interpolating the first and second angle coordinates for the pixel from the angle coordinates [for the polygon vertices] associated with the vertex vector; and

converting the interpolated first and second angle coordinates to scaled angle coordinates.

15. (Twice Amended) A graphics system comprising:

means for associating [vector orientation data] a plurality of vertex angles with [vertices] each vertex of one or more polygons representing an object in an image;

means for indicating color values for a sample of vector orientations, each color value being referenced by one or more orientation dependent color variables;

means for providing orientation perturbations; and

means for converting the plurality of vertex [data] angles for each polygon to a plurality of angle coordinates and perturbation coordinates for each pixel in the polygon;
and

means for combining the angle and perturbation coordinates to provide a color value for each pixel through perturbed color variable.

18. (Twice amended) A system comprising:

a graphics pipeline; and

a memory, in which are stored instructions that are executable by the graphics pipeline to implement a method for assigning a color value to a pixel, the method comprising:

generating color values for a sample of vector orientations, each color value being associated with first and second angle coordinates representing a corresponding vector orientation;

determining a pair of vertex angle coordinates for each vertex vector of a polygon that includes the pixel;

interpolating the pairs of vertex angle coordinates to provide [estimating] first and second angle coordinates for the pixel;

perturbing the first and second angle coordinates to provide modified first and second angle coordinates; and

retrieving a color value for the pixel according to the perturbed first and second angle coordinates.